CLINICAL TECHNIQUE

A Simplified Approach for Sinus Augmentation to Avoid Sinus Membrane Perforation: An Analysis of 400 Cases

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Abstract

Aim: The purpose of this study was to evaluate a new surgical concept with new tools utilized for crestal sinus elevation to determine the incidence of sinus membrane perforation during surgery. A completely new approach, associated with new instruments, allows sinus bone grafting in all cases of atrophy of the posterior maxilla.

Background: Crestal sinus augmentation is frequently required for implant placement in the maxillary molar sites to provide sufficient crestal height to permit implant placement. This is performed in conjunction with implant placement at the same surgical appointment but has the potential for sinus membrane perforation and may be technique sensitive for some practitioners. The technique and instrumentation discussed in the article simplify the procedure and greatly diminish the potential of sinus perforation during treatment.

Clinical technique: Two Kits are discussed, with Kit A utilized to treat maxillary atrophy presenting less than 4 mm of sub-sinus bone height, and Kit B to treat maxillary atrophy presenting more than 4 mm of sub-sinus bone height. The technique involves minimally invasive, simple surgery, using a very precise protocol and instrumentation to permit sinus elevation via a crestal approach, to eliminate sinus membrane perforation potential.

Discussion: The results of this article focused on 100 cases for Kit A and 300 for Kit B, obtaining 97% success in avoiding sinus membrane perforation.

Conclusion: Transcrestal sinus elevation provides a very good alternative utilizing the All Secure Sinus Elevation Kit (ASSEK) A compared to older techniques that have proven themselves to have associated complications, including sinus membrane perforation. The ASSEK B allows you to perform a Summer's sinus elevation approach in direct vision for added safety

Clinical significance: The design of the Kit's components avoids any complications of sinus membrane perforation. The Kit uses a minimally non-invasive surgery, avoiding any healing complications that present with more extensive surgical approaches. Sinus augmentation is frequently required for implant placement in the maxillary molar sites, especially when ridge resorption has occurred. The technique and instrumentation discussed provide a simpler surgical procedure to achieve increased crestal height with significantly decreased sinus perforation potential.

Keywords: Atrophic posterior maxilla, Membrane perforation, Sinus elevation, Sinus pneumatization.

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Introduction

Current treatment utilized to treat atrophy of the posterior maxilla to allow sufficient osseous anatomy for implant placement involves osseous grafting to increase crestal height and width. Two technique types have been utilized depending on the available crestal bone height those being the lateral sinus augmentation technique and the crestal sinus augmentation technique.

Lateral sinus augmentation, also referred to as lateral sinus floor elevation (LSFE), was first reported in the 1970s by Hilt Tatum Jr, and first published by Boyne and James in 1980, and supported in other articles.[1,2] This approach consisted of a full-thickness flap elevated to expose the lateral sinus wall of the maxilla. Access to the maxillary sinus was then accomplished by creation of a window on the lateral sinus wall, while maintaining sinus membrane integrity. An alternative technique is the "wall-off" technique, which has complete removal of the bony island, permitting better access to the sinus.[3–5]

Piezoelectric surgery, rather than rotary instruments, for lateral window preparation and membrane separation has demonstrated a reduction in intraoperative complications, including sinus membrane tearing. The main advantages of the piezoelectric device are its selective cutting action of mineralized tissue and its precise osteotomies enhance surgical control.[6] It has been demonstrated that bone height can be increased by 8–10 mm using the LSFE approach.[7] Lateral sinus floor elevation is indicated when minimal crestal bone height is present. However, the LSFE approach has some disadvantages as it is often associated with substantial patient morbidity. Lateral sinus floor elevation requires a wide mucoperiosteal flap with at least one vertical releasing incision for the creation of a lateral wall bony window. This may result in an increased risk of postoperative pain, facial edema, delay

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in healing, bleeding, and postoperative infection.[8,9] Additionally, up to 58% perforation of the sinus membrane and antral artery involvement (21%) have been reported.[9] An alternative technique when the crestal height of 4 mm or greater is present is the Summer's technique.

The transcrestal sinus floor elevation (TSFE) approach was introduced by Tatum in 1976 and modified by Summers in 1994.[10–12] Unlike LSFE, where a buccal bone plate osteotomy must be done, the TSFE involves a crestal approach to the sinus membrane through the implant osteotomy drilled. This involves fracturing the sinus floor using a set of osteotomes of increasing diameter to elevate the floor of the sinus, while increasing the density of the surrounding maxillary bone, which results in better primary stability of the implants. Implant placement at the same surgical appointment is achieved. This technique is less invasive than LSFE with much less incidence of sinus membrane perforation. As no antral artery is in the surgical area, potential damage as reported in LSFE is eliminated. The disadvantage of this technique is blind surgery, as the membrane is not visible to the practitioner during treatment

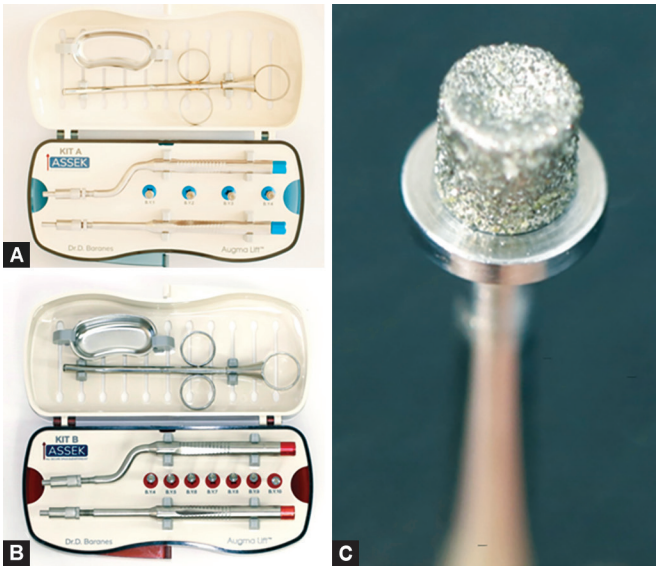
Summers modified Tatum's TSFE technique by introducing a more conservative and less invasive approach utilizing osteotomes instead of traditional rotary instruments. While Tatum's technique involved the use of drills to access the sinus floor, Summers replaced these with manually driven osteotomes, allowing for controlled fracture and elevation of the sinus floor. This modification enabled not only access to the sinus but also facilitated lateral and apical bone compaction, improving primary implant stability, which is beneficial in cases with less dense maxillary bone (types III and IV).

Following analyzing different techniques, the authors developed a modified technique to avoid perforation of the sinus membrane, which is an essential reason for failures of the older techniques. Indeed, in LSFE, the percentage of perforation of the sinus membrane reached 58.3%.[13] Whereas, in the crestal approach, perforation was reported at 22%.[13]

Clinical Technique

The All Secure Sinus Elevation Kit (ASSEK) (ASSEK Technical, Jerusalem, Israel) allows the surgeon to carry out each step of the elevation of the sinus floor using secure tools, avoiding any perforation or tearing of the membrane. B.Y. drills for Kit A (Fig. 1A) or B.Y.S for Kit B (Fig. 1B) are diamond drills that can gently squeeze the bone crestally, due to their blunt ends (Fig. 1C). The central part of the terminal end of the drill is concave, allowing a bony disc to be formed, which remains in contact with the sinus membrane. This bony disc is in contact with the sinus membrane.

When the B.Y. drill enters the sinus, it grazes the membrane without tearing it (Figs. 2A – 1 and 2). Upon withdrawal of the B.Y. drill, we can directly observe a bony disc surrounded by a blood-tinged ring (the sinus membrane). The preparation phase of the opening is very safe, as the drill is diamond-coated and therefore mills the bone rather than cutting it like traditional metal drills. The grain size of the diamond coating is medium, allowing it to gently contact the membrane. The central part of the upper face of the drill is concave, so only the periphery encounters the membrane. The periphery of the drill is dull and non-aggressive, unlike the sharp cutting edges of traditional drills. When the B.Y. drill advances, its penetration is immediately stopped by contact of the stopper on the crest, ensuring a very safe procedure. The concave part of the drill leaves a bony disc at the center of the opening, in contact with the membrane.

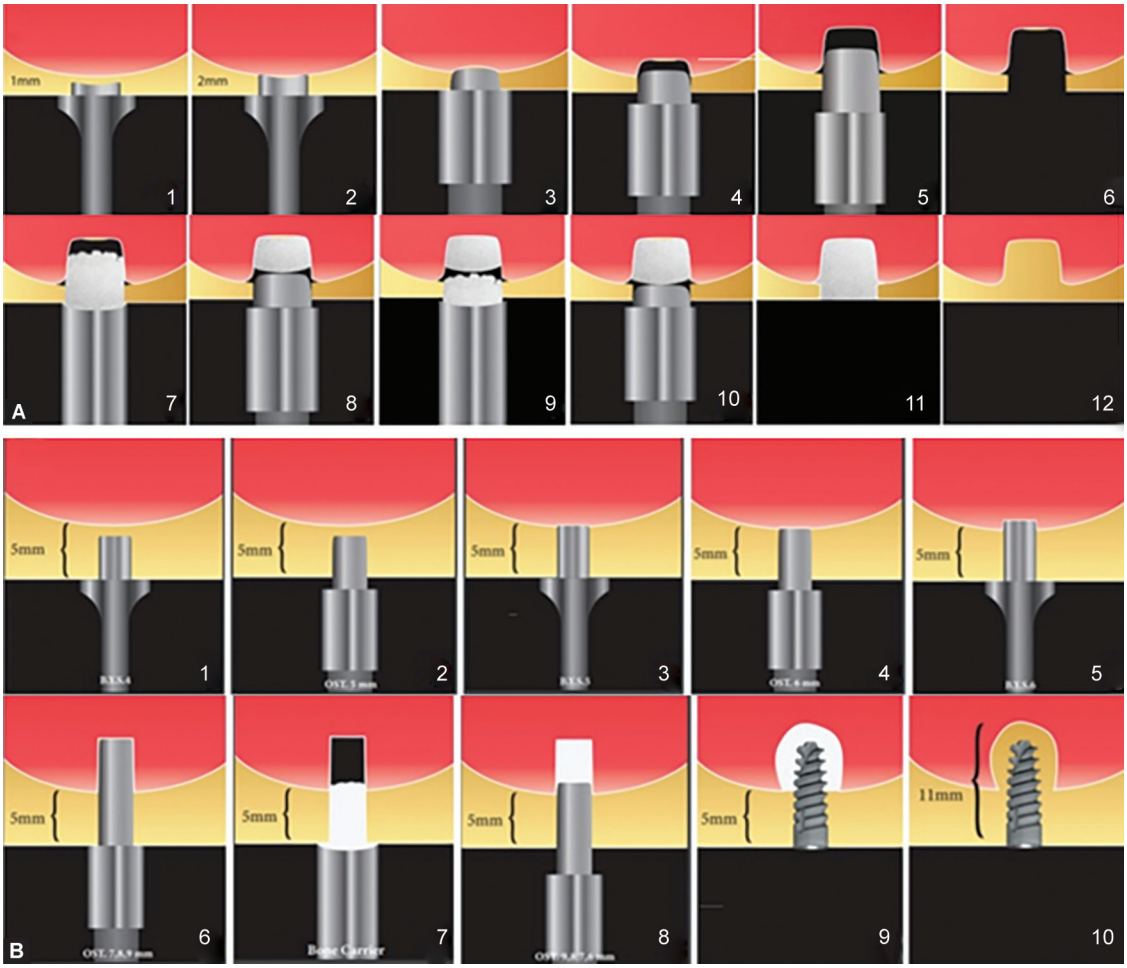


Figs 1A to C: (A) All Secure Sinus Elevation Kit A is utilized for sinus elevation and graft placement when implant placement will not be performed at the same surgical visit and site healing is required before implant placement; (B) ASSEK B is utilized for sinus elevation and simultaneous implant placement; (C) The concave tip of the B.Y. drill (Kit A)

In the second step, the elevation of the sinus membrane, the Kit provides two osteotomes: one straight and one bayonet-shaped. These osteotomes have millimeter markings and are equipped with a stopper to prevent unintentional sinus penetration. The active tip of the osteotome is slightly convex and has a dull periphery. These non-aggressive osteotomes push the bony disc created during the B.Y. drill preparation; thus, the osteotome is never in direct contact with the membrane.

Elevation of the sinus membrane is done progressively, millimeter by millimeter, to avoid any membrane perforation (Fig. 2A – 3 to 5). The practitioner repeats this maneuver five times to achieve a final elevation of 5 mm, to respect the elasticity of the sinus membrane (Fig. 2A – 6). During membrane elevation, bleeding appears at the opening, since the membrane contains capillaries, its elevation causes slight bleeding, which is a sign of membrane integrity. After the first two stages, osseous disk formation with access to the sinus membrane and the 5 mm elevation of the membrane, a third stage is initiated. This involves filling the space created by the elevation with a bone graft material.

The graft material recommended for bone grafting must not be aggressive yet must fill the space prepared by the osteotomes (Fig. 2A – 7). For this study, Bond Apatite (Augma Biomaterials, Caesarea, Israel) was selected due to its resorbable nature over time, allowing vascularization of the graft and replacement with host bone (Fig. 2A – 8 to 11).[14–16] Additionally, as the material sets hard, it serves as a barrier and avoids the use of a separate resorbable membrane. Should immediate implant placement not be planned due to thin crestal host bone at the time of surgery, the soft tissue is closed over the crestal sinus augmentation site and allowed to heal for later implant placement following graft healing (Fig. 2A – 12). When implant placement is achievable as sufficient crestal bone height (5 mm) is present before sinus augmentation, a similar sequence is followed to crestally elevate the sinus, augment that area, and place the implant in a single surgery (Fig. 2B – 1 to 10).



Figs 2A and B: (A) Clinical steps for ASEEK Kit A usage; (B) Clinical steps for ASEEK Kit B usage

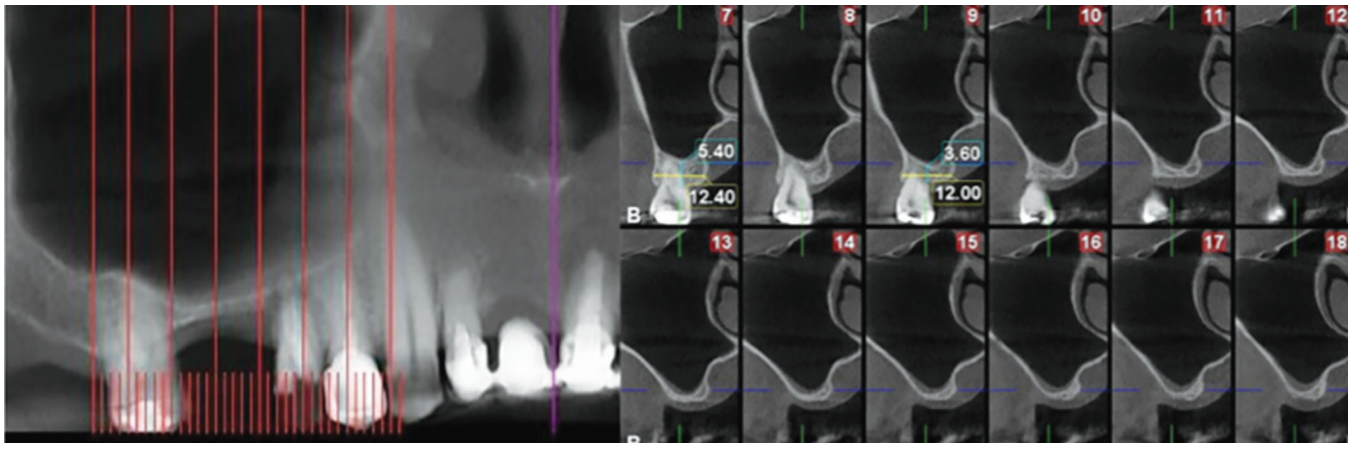


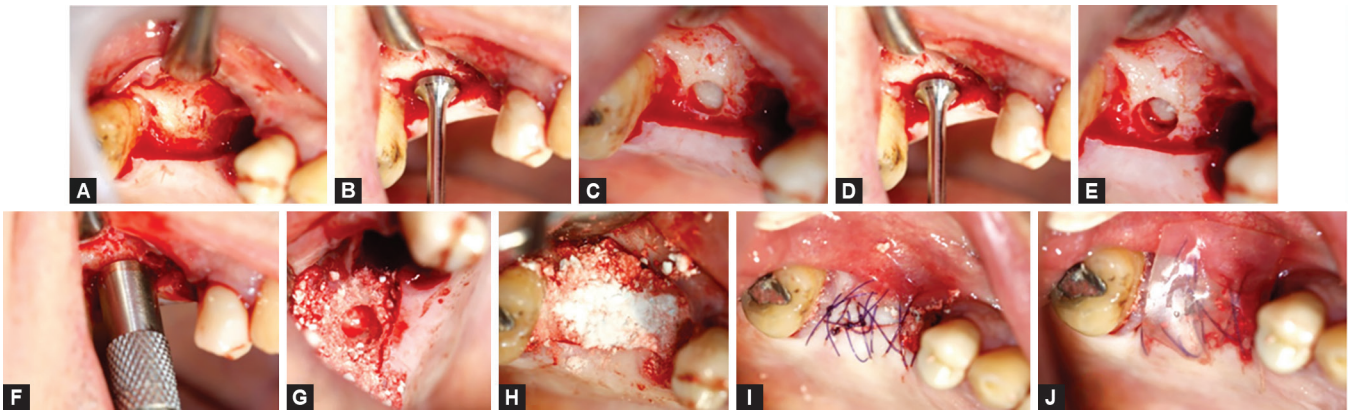
Fig. 3: Cone beam computed tomography radiographs demonstrating minimal crestal bone in the posterior maxilla

The clinical technique begins with a cone beam computed tomography (CBCT) scan to allow analysis of the area to receive the crestal sinus augmentation and determine the anatomy present (Fig. 3). Following the local anesthetic being administered, a crestal incision is made, and a full-thickness flap elevation is performed (Fig. 4A). An initial osteotomy preparation was performed with a B.Y.1 drill in Kit A (Fig. 4B). The osteotomy was completed with the subsequent drill B.Y.2 to create the bone disk. (Figs 4C and D). Then, the membrane is pushed back by 5 mm in total according to the protocol (Fig. 4E), Bond Apatite is mixed, and a portion of the graft is carried to the osteotomy (Fig. 4F). Additional graft material is then placed into the site, and an osteotome with a set stopper is

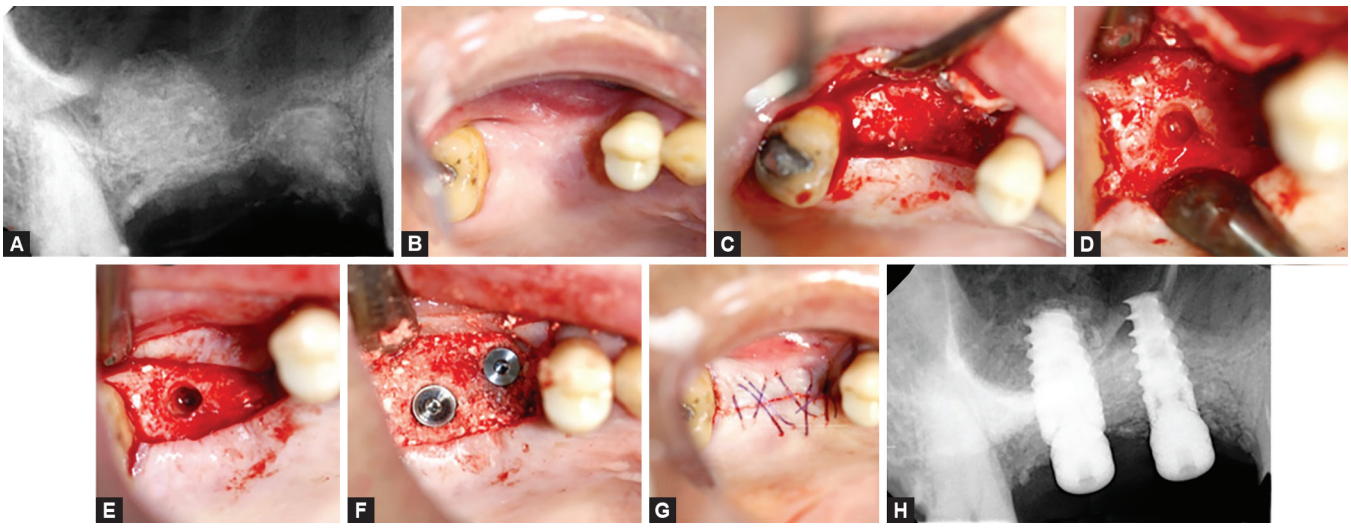
advanced toward the sinus floor (Fig. 4G). Incremental elevation with graft placement is completed. The osteotomy is then filled with additional Bond Apatite to the crestal level to close the entrance of the osteotomy (Fig. 4H). The flap is reapproximated to close the site, and sutures are placed under compression (Fig. 4I). A piece of Augma Shield (Augma Biomaterials) is then placed over the sutures to protect the site from oral bacteria and other salivary components during the initial soft tissue healing phase (Fig. 4J). A periapical radiograph is then taken to document sinus elevation and augmentation.

At 4 months post sinus elevation, the patient presents for phase 2 of the surgical treatment, which would include additional sinus elevation and implant placement. A periapical radiograph is taken to verify sinus augmentation at the desired area of the ridge (Fig. 5A). The soft tissue overlying the augmented ridge should be without gingival inflammation, indicating site healing (Fig. 5B). Following local anesthetic placement, a full-thickness flap is elevated similar to that during phase 1 surgery (Fig. 5C). As was performed in the prior surgery, using Kit B, a diamond drill B.Y.S. is used for an osteotomy to be in contact with the sinus floor (Figs 4D and E). The choice of the B.Y.S. drill will depend on the sub-sinus bone height. For example, if the CBCT shows a sub-sinus bone height of 6 mm, we will use the B.Y.S.6 drill. Drilling will continue until the drill's stopper is in contact with the crest. Then, a 3.2 mm diameter osteotome with a concave and non-aggressive tip will be prepared with a 7 mm stopper. If the stopper is in contact with the crest, it indicates that the membrane has been pushed up by 1 mm. This membrane elevation procedure will be repeated 4 more times.

If the stopper of the osteotome remains distant from the crest, the B.Y.S.8 drill must be used, and the protocol should be continued accordingly. Once the membrane has been elevated by 5 mm, the bone grafting stage begins. For the graft, 1 mm of the osteotome's height will be removed before each grafting step. Then, the implant will be placed during the same session. Further elevation is performed using the osteotome instruments in Kit B. Bond Apatite



Figs 4A to J: (A) Flap elevation to expose the crestal ridge; (B) Initial osteotomy preparation with the Kit A drill; (C) The crestal aspect after utilization B.Y.1 drill; (D) Osteotomy drill utilized B.Y.2 drill; (E) Crestal aspect after B.Y.2 plunged (bone disk); (F) Utilization of the osteotome with stopper to elevate the membrane; (G) Elevation and graft placement has been completed; (H) The osteotomy was filled with additional graft material; (I) Soft tissue repositioned and sutured under compression; (J) Placement of Augma Shield to protect the site during initial soft tissue healing



Figs 5A to H: (A) Periapical radiograph following sinus elevation and placement of Bond Apatite grafting; (B) Crestal appearance at 4-months following initial crestal elevation with Kit A; (C) Following flap elevation to expose the crest; (D) Initial osteotomy created to contact with the sinus membrane; (E) Following elevation with the instruments in Kit B; (F) Implants placed and additional Bond Apatite placed crestally; (G) Soft tissue closed under compression with sutures; (H) Periapical radiograph taken following additional sinus elevation and implant placement

is placed into the osteotomy and compacted apically, followed by placement of the implant into the site (Fig. 5F). Additional Bond Apatite is placed over the crest to fill any implant thread exposure. The flap margins are reapproximated, and sutures are placed under compression (Fig. 5G). A periapical radiograph is taken to document the new sinus floor position and implant placement (Fig. 5H).

The protocol followed in the study involved, when less than 4 mm of available crestal height is present, a delayed implant placement protocol is followed after sinus elevation. A crestal incision is made mesially-distally, slightly displaced in the palatal direction. A full-thickness flap is elevated to allow visualization of the crestal and buccal bone to avoid any error in osteotomy preparation. Radiographically, the crestal height between the inferior aspect of the crest and the sinus floor is determined and set at 1 mm less than the measured height. The stop is set for this length on a B.Y.1 drill on the surgical unit with external irrigation set at a speed between 600 and 1,000 rpm. The diamond drill is utilized at the planned site until the stop comes into contact with the crest. When the drill plunges (sensation that the drill penetrates, but penetration is blocked by the stop), this is the sign that contact with the sinus membrane has occurred. Clinically, this indicates the bony disc is surrounded by a bloody sinus membrane. This bone disc and its membrane are pushed back using an osteotome with the stop set at the same length as the drill was set, plus 1 mm to each pass of the osteotome, not exceeding greater than 5 mm of the height of the crest. The graft material (Bond Apatite) is prepared before bringing it to the mouth using a graft syringe. The length is corrected by 1 mm, which is reduced from the last length of the osteotome to allow graft materials to be pushed inside the osteotomy. This is repeated, removing 1 mm of length for each additional graft placement into the osteotomy until the osteotomy is filled to the crestal surface. Dry gauze is then placed over the crestal graft material to remove any residual water from the graft and to close the entrance of the site. The soft tissue is then closed with sutures under compression.

At 4 months post-surgical sinus elevation, ASSEK B is utilized for a Summer's crestal approach and implant placement. Kit B protocol (when the bone height below the sinus is greater than 4 mm). A similar protocol as previously described is performed to expose the crestal bone. A B.Y.S. diamond drill is placed on the surgical handpiece, and a speed of 600–1,000 rpm is set. Under external irrigation, the drill creates a 2.8 mm wide osteotomy at the crest. The choice of the B.Y.S. drill will depend on the sub-sinus bone height. For example, if the CBCT shows a sub-sinus bone height of 6 mm, we will use the B.Y.S.6 drill. Drilling will continue until the drill's stopper is in contact with the crest. Then, a 3.2 mm diameter osteotome with a concave and non-aggressive tip will be prepared with a 7 mm stopper. If the stopper is in contact with the crest, it indicates that the membrane has been pushed up by 1 mm. This membrane elevation procedure will be repeated 4 more times. If the stopper of the osteotome remains distant from the crest, the B.Y.S.8 drill must be utilized, and the protocol is continued accordingly. Once the membrane has been elevated by 5 mm, the bone grafting stage begins. For the graft, 1 mm of the osteotome's height will be removed before each grafting step. Then, the implant will be placed during the same session.

Kit B is used either 4 months post-operatively after using Kit A, or on patients who initially had a sub-sinus bone height greater than 4 mm. In the study, 300 cases that used Kit B, only one membrane perforations were observed. All four cases of membrane perforation occurred during grafting of the material.

Discussion

The study involved 100 patients who were treated with Kit A and 300 patients treated with Kit B. All patients treated with Kit A had a crestal bone height of 1–4 mm, and all patients treated with Kit B had a crestal bone height greater than 4 mm. The patients treated with Kit A, which allowed an increase in crestal height by 3–5 mm. The measurements of bone heights obtained after sinus floor elevation using Kit A were carried out clinically during the second session, four months postoperative, using Kit B. For example, when the B.Y.S.7 drill sinks in, it indicates that the sub-sinus bone height was 6.5 mm. This measurement method was preferred over CBCT, which remains approximate, with a margin of error that can reach up to 2 mm. The results showed a bone height gain ranging between 3.5 and 6 mm.

The perforation of the sinus membrane for the first patient occurred during the elevation of the membrane within the first millimeter, due to a thin membrane, as confirmed clinically. The other two perforations occurred during the grafting stage of the material. These cases were subsequently treated 4 months later with Kit B, allowing placement of the implant.

The first portion of the study consisted of checking for perforation of the membrane according to the steps of the protocol. Verification of the integrity of the sinus membrane during the first two stages of Kit A, preparation of the osteotomy, lifting of the sinus membrane, and carried out by the practitioner in direct vision. Verification of the integrity of the membrane during the third step (sinus graft) is verified radiographically; the material is well delimited by the membrane and in the shape of a dome. Evaluation of the 100 cases treated with Kit A, found that only one perforation occurred (Table 1).

Table 1: Perforations identified in the 100 cases utilizing Kit A (left) and perforations identified in the 300 cases utilizing Kit B (right)

Stage protocol	*Number of perforations membrane*	*Stage protocol*	*Number of perforations membrane*
Preparation of the osteotomy Strawberries B.Y. 1, 2, 3, 4	0	Preparation of the osteotomy B.Y.S. 4, 5, 6, 7, 8, 9	0
Elevation of the membrane Osteotome 3.7 mm	1	Elevation of the membrane Osteotome 3.2 mm	1
Grafting of the osteotomy Bond Apatite	1	Grafting of the osteotomy Bond Apatite	0
Closure of the osteotomy Bond Apatite	0	Implant placement DIS remix	

Verification of the integrity of the sinus membrane during the first step of Kit B is done directly by the practitioner and by the Valsalva test. Confirmation of the integrity of the sinus membrane during the bone grafting stage and placement of the implant is done radiographically. Evaluation of the 300 cases treated with Kit B noted a single case of sinus membrane perforation (Table 1).

Conclusion

Transcrestal sinus elevation provides a very good alternative utilizing the ASSEK A compared to older techniques that have proven themselves to have associated complications, including sinus membrane perforation. The design of the Kit's components and detailed technique avoids any complications of sinus membrane perforation. The Kit uses a minimally non-invasive surgery, avoiding any healing complications that can present with more extensive surgical approaches. The ASSEK B allows you to perform a Summer's sinus elevation approach in direct vision for added safety.

As with all treatment procedures, case selection is important to achieve the desired results clinically. Crestal sinus elevation techniques require a minimum crestal height prior to utilizing the technique. A minimum of pre-treatment crestal height of 3–5 mm has been advocated with crestal sinus elevation to decrease the potential for membrane perforation. Should less than that be present, performing initial augmentation with grafting is recommended, followed by site healing before additional sinus elevation is performed to allow implant placement at that 2nd surgery.

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